NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

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REPORT NUMBER 699

MOBILE PSYCHOACOUSTIC LABORATORY

by

Paul F. Smith

Bureau of Medicine and Surgery, Navy Department
Research Work Unit M4305.08-3008DEE5.03

Released by:

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Officer in Charge
Naval Submarine Medical Research Laboratory

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SUMMARY PAGE

THE PROBLEM:

To develop a capability for conducting psychoacoustic research at sites remote from the Naval Submarine Medical Research Laboratory.

FINDINGS:

A mobile psychoacoustic laboratory was constructed which provides adequate conditions for psychoacoustic research under field conditions.

APPLICATION:

The mobile psychoacoustic laboratory permits the collection of various kinds of data under field conditions.

ADMINISTRATIVE INFORMATION

This investigation was conducted as part of Bureau of Medicine and Surgery Research Work Unit M4305.08-3008DEE5 - Development of Damage Risk Criteria and Habitability Standards for Exposure to Sonar Transmissions. This report has been designated as NAVSUBMEDRSCHLAB Report No. 699. It is Report No. 3 on this Work Unit and was approved for publication as of 8 February 1972.

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ABSTRACT

A mobile laboratory that provides an adequate environment for a variety of psychoacoustic measurements has been constructed. The mobile unit is used for psychoacoustic and bioacoustic field studies. This laboratory houses a 10-man audiometric booth. In addition to space within the booth, there are in excess of 120 square feet of floor space available for installation of equipment. Most clinical or experimental audiometric and otologic procedures and group audiometric tests can be administered within the laboratory. Cables may be run to apparatus set up away from the trailer permitting detailed environmental noise analyses, acquisition of bioacoustic data, conducting underwater hearing and communications experiments, etc.

MOBILE PSYCHOACOUSTIC LABORATORY

The Auditory Research Branch of the Naval Submarine Medical Research Laboratory has been conducting research on underwater hearing in man and on the effects of intense sound sources on the hearing of divers. Conduct of this research has required that data be collected at a number of sites remote from the Laboratory. Typically, in conjunction with obtained underwater data, measurements of air conduction hearing are required. A quiet environment is needed for the latter tests. Such environments are not generally available away from the laboratory. The Mobile Laboratory described below has been designed to furnish the necessary test environment and space for audiometric and other electronic equipment.

Design and Construction

The laboratory is built on a surplus 27 1/2' low-bed trailer. The deck of the trailer, which forms the floor of the laboratory is 1 1/2" oak planking except for the forward 9 1/2' which is 1/4" steel plate. The walls and ceiling are constructed of one-inch thick sheet styrofoam sandwiched between .060 gauge aluminum sheeting. Total wall thickness is 1 5/8" including a 1/2" dead air space. This wall construction provides thermal and acoustical insulation.

As shown in Figure 1, the Mobile Psychoacoustic Laboratory consists of three compartments. The forward compartment is primarily an equipment and control space, the middle compartment is a sound-proofed booth, and the after compartment is a small entry foyer and storage space.

The forward compartment consists of two areas, an upper area built on the goose neck of the low bed and a smaller area on the deck of the low bed. The upper area is a space of slightly more than 8' X 8' square and is the primary instrumentation area. That is, electronics control apparatus, stimulus generating experiment and calibration equipment is usually mounted on radio relay racks in this area. This area also contains the heating and air conditioning equipment and the electrical power distribution panel. A three foot square doorway located on the starboard side of the compartment permits loading and removal of equipment.

The lower area of the forward compartment has a floor space of about 4' X 8'. This area contains a 3' X 7' door in the port wall and is used as an auxiliary entry to the audiometric booth as well as the primary access to the forward compartment. The area also contains a small cable port located in the floor on the starboard side. The primary function of this area is to provide a space from which experiments may be controlled. By mounting control apparatus on the lower portion of equipment racks mounted on the floor of the upper area but facing into the lower area a control console is assembled. This console would contain those controls (oscillators, decade attenuators) which need to be manipulated

during an experiment, as well as required monitors such as frequency counters, volt meters, oscilloscopes, etc. All electronics whose controls are not often varied are mounted in racks in the upper area.

The door to this area has a large window which serves as an observation port. A viewing port is also located in the starboard wall of the lower forward compartment. These windows permit observation of activities outside of the laboratory. In a typical application, such as an experiment in underwater hearing, the experimenter would be in the laboratory operating electronic equipment and the diving supervisor would be outside of the trailer. Direct visual contact between the experimenter and the diving supervisor contributes to the smooth execution of the experimental plans.

The forward compartment is large enough to accommodate a wide variety of psychophysical experimental set-ups. It is possible to conduct two independent experiments or measurement procedures within the mobile laboratory simultaneously, provided one procedure does not require use of the audiometric booth.

The booth which comprises the middle is an Industrial Acoustics Company, Inc., Model 10-MR single-walled ten-man audiometric booth with an interior floor space of about 7' X 11'. It has two doors, one opening into the forward compartment and one opening into the after compartment. It is mounted on three shock-mount rails running the length of the unit. These shock mounts are the only connection between the booth and the remainder of the laboratory with the exception of power and signal cables and cross-ventilation ducts.

This compartment contains 10 subject spaces separated one from the other by draw curtains. The curtains may be opened to provide a single working area.

Through-the-wall connectors provide 72 low-amperage and twelve high-amperage signal channels. An additional small stuffing box permits passage of miscellaneous cables through the wall to the control space.

The booth has two independent ventilating circuits. Air is pumped from the forward and after compartments into the booth and then through outlets to the exterior of the trailer. These systems are virtually noiseless and do not interfere with audiometry over the 125 to 8000 Hz range.

The third or after compartment is a small space of about 3' X 8'. It contains a door to the exterior. This arrangement allows subjects to enter and leave the booth without passing through the forward control room. This is highly desirable when the experimental procedure demands air conduction testing of a diver immediately following a dive, as it often the case. The after compartment also provides extra storage space. One of the low pressure ventilator intakes for the ten-man booth is also located in the after compartment. A crawl space above the audiometric booth as well as space between the walls of the booth and the walls of the trailer itself permits movement of air from the forward to the after compartments.

The after compartment also contains power outlets and is large enough that moderate amounts of equipment may be operated there. This becomes a necessity when very low levels of signals are being measured at the same time that high signal levels are being generated by stimulus apparatus. In such situations, it is often necessary to physically separate the high level and low level systems to prevent electrical artifacts from interfering with the low level systems.

The power input system of the laboratory is designed to take power from any 60 cycle alternating current line of 440, 220, or 110 volts. A 100-foot Neoprene coated cable consisting of three #8 wires connects to a Russell Stoll #7277 receptacle mounted on the front of the trailer. The input power is then connected through a 600 volt, 2 pole, 60 amp fused switch to the primary leads of a 5 KVA GE Type 9721A1004 transformer. By appropriate input tap selection the transformer will produce 240 and 120 VAC with either 440 volt or 220 volt input. The output of the transformer is delivered to a panel which distributes the power through circuit breakers throughout the laboratory. Four 115-volt outlets on the exterior of the trailer permit the operation of external equipment and lights for night diving operations.

All critical equipment racks are powered through a General Radio Type 1582-A Variac Automatic Voltage Regulator. This Variac automatically compensates for AC line-voltage fluctuations over a 82 to 124% correction range with an accuracy of .5% of nominal output voltage, (115 volts $\pm$ 10% adjustable). Such fluctuations are occasionally encountered when taking power from diesel generators or other unreliable sources and can have a severe effect on the operation of calibration and control equipment.

Lighting consists of fluorescent lights with each of the ten subject stations being separately lit. For use in transit, or when not powered by an AC source, the forward and after compartment also contain 12 volt DC dome lights. The trailer is also equipped with conventional external running lights.

A heat pump mounted in the forward compartment provides heating and/or cooling as required by weather conditions. The audiometric booth which comprises the middle compartment draws conditioned air from the forward and/or after compartments and exhausts to the outside of the trailer through canvas duct connectors. The rate of flow of air can be controlled by shutting down the exhaust system or by turning one or both ventilators on or off.

The heat pump used is a Carrier Model 51PQ2703 which operates on 220 volts single phase and delivers approximately 20,000 BTU cooling. This has been found to be adequate for all environments encountered to date. The units heat output is not adequate to maintain the entire laboratory at comfortable temperatures in the coldest winter months. It is capable of maintaining a 30°F differential between inside and outside temperatures on moderately windy days. The heat pump is therefore supplemented by a 5600 Watt, 220 Volt space heater.

Acoustic Evaluation

The attenuation provided by the booth was determined by measuring from the outside of the booth the sound pressure level of noise generated within the booth. While noise from a Grason-Stadler Model 901B noise generator was passed through a United Transformer Corporation Model LS-33 impedance matching transformer and amplified by an Altec Model 1569A amplifier. The signal was used to drive a University Model 315C tri-axial speaker which was set up in front of the rear door of the booth projecting toward the front door. During all measurements the rear door was closed. The sound pressure levels in the octave bands whose center frequencies are shown in the column headed "Band" in Table 1 were measured with the front door open (level 1) and then again with the front door closed (level 2). These measurements were made with all external doors and hatches of the trailer closed and with the heat pump turned off. Measurements were taken on a quite windless evening in the spring. A General Radio Type 1558-BP Octave Band Analyzer was used to measure the sound pressure levels. This instrument could not measure noise level within the trailer. The decibel difference between level 1 and level 2 is shown in Table 1 in the column headed "Attenuation" and is presumed to be an estimate of the attenuation of external noise provided by the booth.

Table 1: Attenuation of Noise Provided by the Ten-Man Booth. See Text for Description of Headings.

BAND	LEVEL 1	LEVEL 2	ATTEN-UATION
32	54	45	9
63	66	45	21
125	79	53	26
250	82	52	30
500	80	45	35
1000	85	49	36
2000	84	50	34
4000	83	47	36
8000	75	45	30
16000	66	45	21

The sound attenuation provided by the trailer itself is considerable. On one occasion a large vacuum-cleaner type machine was in use cleaning leaves from around and under the trailer. This machine produced noise levels which varied between 94 and 117 dB in octave bands centered at 500, 1000, and 2000 Hetz as measured along one side of the trailer. Within the trailer at various places within the forward equipment space the noise level varied from 60 to 87 dB indicating an attenuation of 30 to 34 dB over the three octave bands. Combined with the values in Table 1, it is seen that this yields a total attenuation of 64 to 70 dB from the external environment to the interior of the single walled booth. It is customary to measure air conduction thresholds in the mobile laboratory with a headset consisting of some form of circum-aural muff which provides a minimum of 30 dB attenuation at frequencies above 500 Hz. Thus, valid air conduction audiometry can be accomplished with the mobile laboratory immersed in a sound field approaching octave band levels of 100 dB re .0002 N/m^2.

Utilization

There is no specialized equipment mounted in the Mobile Psychoacoustic Laboratory. Rather, the trailer is equipped according to the needs of particular research projects. The forward and after compartments contain a total of more than 120 square feet of floor space all of which is available for installation of experimental apparatus. In most applications, only a fraction of the available space is utilized. Most clinical and experimental audiometric and otologic procedures may be accomplished in the laboratory, including group audiometry. Among the works conducted in the laboratory have been an experiment on changes in the stapedius response which required measurement of the acoustic impedance of the ear, and a shaping procedure for running mink in a discrimination apparatus.

More usually, the laboratory is used in studies of underwater hearing, especially studies of the effects of intense underwater sounds on divers. Figure 2 was taken during one such study. The trailer was mounted on a barge along with a number of equipment and living shelters and a 30 Kilowatt generator. The barge was anchored in a bay in about forty-five feet of water. A diving stage containing an underwater sound projector, a hydrophone, a signal light, and two underwater switches was suspended from the barge. Cables for the underwater equipment ran to the Mobile Laboratory. Using appropriate electronics equipment in the laboratory it was possible to measure underwater hearing thresholds of divers. A second set of equipment was used to measure air conduction thresholds in the audiometric booth. A third set of electronics was used to measure underwater ambient noise levels. All

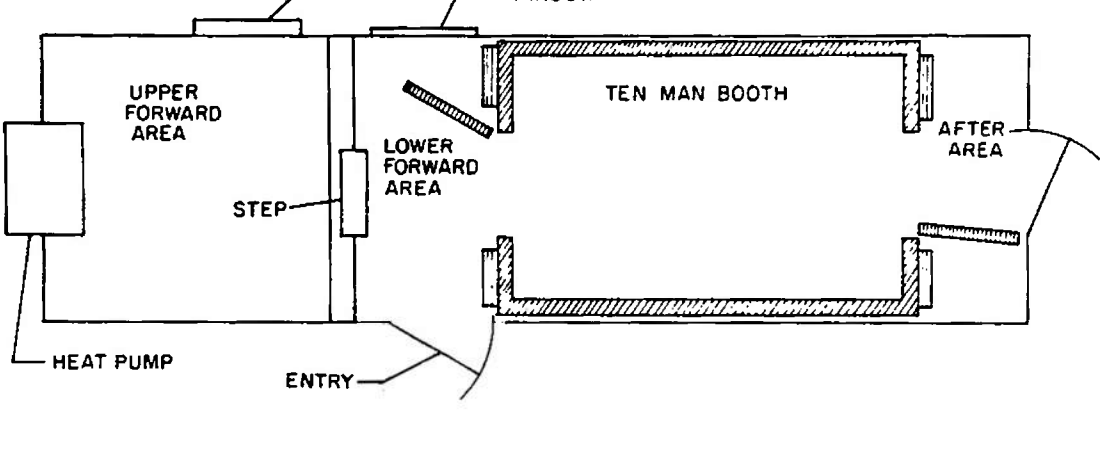

Fig. 1. Schematic diagram of the mobile psychoacoustic laboratory. Not to scale.

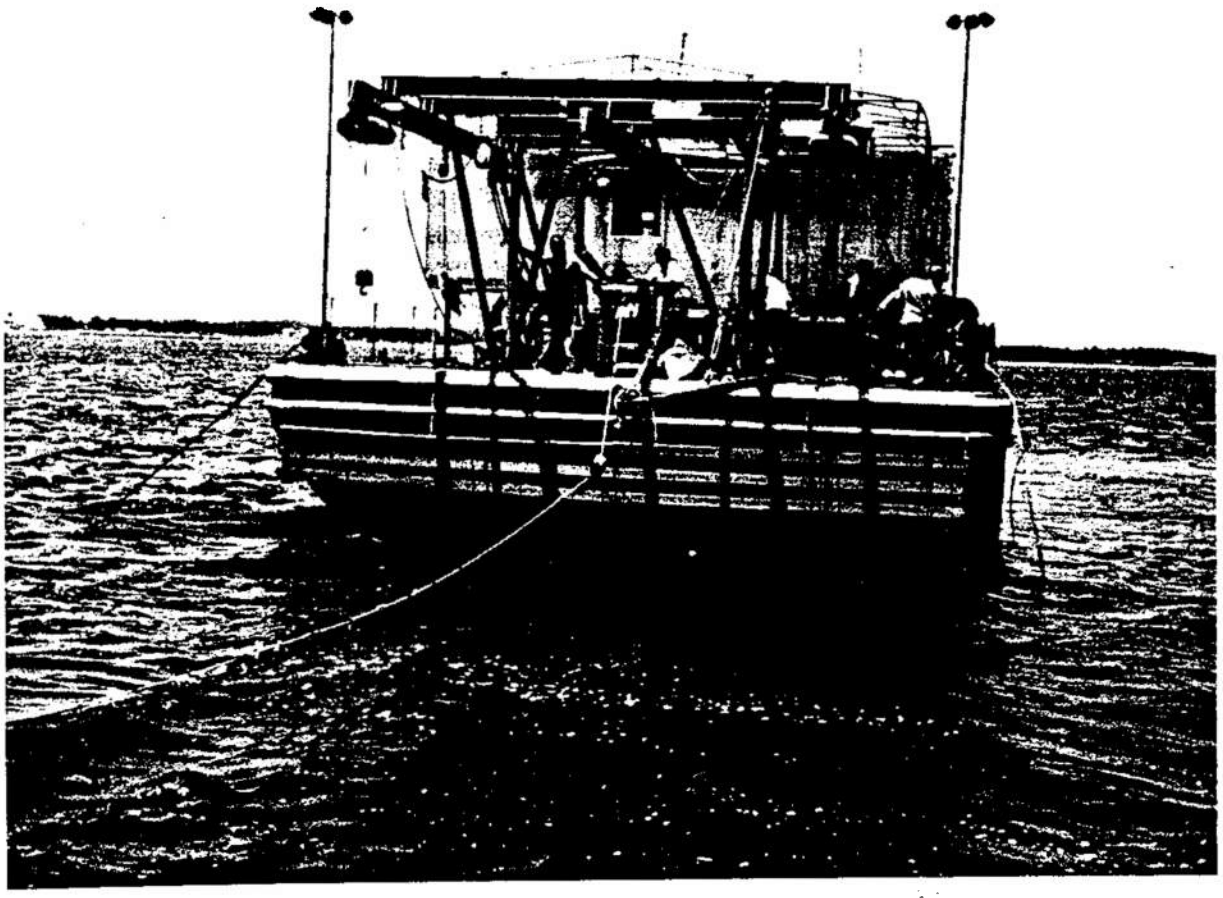

Fig. 2. Mobile Psychoacoustic Laboratory arriving at the Naval Submarine Base, New London, Groton, Connecticut.

three measurement procedures could be, and were on occasion, conducted simultaneously by a single experimenter.

When not in use in field studies, the mobile psychoacoustics laboratory is parked outside of the Sound Suite of the Auditory Research Branch, NAVSUBMEDRSCHLAB on an especially prepared pad. The mobile unit is maintained in a powered state and is used as additional laboratory space. Figure 3 shows the trailer being backed onto the pad.

Fig. 3. Mobile Psychoacoustic Laboratory in use during a study conducted in St. Andrews Bay, Panama City, Florida.

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A mobile laboratory that provides an adequate environment for a variety of psychoacoustic measurements has been constructed. The mobile unit will be used for psychoacoustic and bioacoustic field studies. The laboratory houses a 10-man audiometric booth. In addition to space within the booth, there are in excess of 120 square feet of floor space available for installation of equipment. Most clinical or experimental audiometric and otologic procedures and group audiometric tests can be administered within the laboratory. Cables may be run to apparatus set up away from the trailer permitting detailed environmental noise analyses, acquisition of bioacoustical data, conducting underwater analyses, and communications experiments, etc.

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